

Citation:

Mylius SD, Nauta MJ, Havelaar AH. Cross-contamination during food preparation: A mechanistic model applied to chicken-borne *Campylobacter*. *Risk Anal.* 2007; 27 (4): 803-813.

PubMed ID: [17958493](#)

Study Design:

Meta-analysis / Quantitative microbiological risk assessment

Class:

M - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To provide a simple model for cross-contamination that can easily be extended to take more complicated scenarios into account, and that can be used as a framework for other cases of cross-contamination.

Inclusion Criteria:

Not described.

Exclusion Criteria:

Not described.

Description of Study Protocol:**Recruitment**

This risk assessment study is part of the *Campylobacter* Risk Management and Assessment (CARMA) project, a collaborative project in the Netherlands that aims to compare the efficacy of a set of intervention measures along the food chain.

Design

Meta-analysis/quantitative microbiological risk assessment.

Blinding Used

Not applicable.

Intervention

Simulated the process of preparing a meal, partly consisting of a piece of chicken breast, which is cut into pieces and fried and a salad, which is consumed raw. The cooking is done by a single person, who also consumes the meal on his or her own.

Statistical Analysis

- Simulation model parameters:
 - Exposure setting: The setting of the model is a domestic kitchen with a number of objects that can be contaminated, together with a number of actions or kitchen routines, contributing to cross-contamination between these objects. For simplicity and because of data scarcity, only a small number of objects and actions were considered
 - Only viable colony-forming units (CFUs) of *Campylobacter* were counted, assuming that all CFUs are equal and do not differ in adhesion properties and other characteristics. Also, the different among stages in the cell cycle, etc. were not distinguished. Because of the short time needed for the preparation of a meal, the growth or inactivation of *Campylobacter* was neglected
 - The most important parameters of the model are transfer probabilities of CFUs between kitchen objects and the probability that actions are performed. The former depend on the type of action being performed and the latter depend on the types of actions that were performed just before.
- Simulation procedures:
 - Assuming that initially only chicken breast is contaminated with *Campylobacter*, the risk of infection of the person who prepares and consumes the meal, by bacterial transfer from chicken to salad was estimated. We neglected infection due to insufficient heating of chicken meat, inhalation of aerosols, finger licking, etc. A dose-response model was included in the simulations to have a scalar criterion by which we can measure the effect of parameter changes and other scenarios
 - The simulation procedure consists of a large number (typically 10^4 to 10^5) of Monte Carlo (MC) realizations of preparing a “model meal.” Every single realization consists of the following steps:
 1. Calculation of contamination level of chicken breast
 2. Calculation of performed actions
 3. Calculation of cross-contamination routes
 4. Calculation of contaminated objects
 5. Calculation of number of people infected. The simulation model was programmed in Mathematica (Wolfram Research Inc., 2003).

Data Collection Summary:

Timing of Measurements

Not applicable.

Dependent Variables

Calculation of number of people infected given the parameters below.

Independent Variables

- Distributions of *Campylobacter* viable colony-forming units (CFUs) on (a) chicken breast, (b) cook's hands and (c) salad after food preparation

- Cross-contamination routes:
 - Transfer from chicken to hand
 - Transfer from chicken to cutting board
 - Persistence on hand
 - Transfer from hand to salad
 - Transfer from hand to tap
 - Persistence on salad
 - Transfer from cutting board to salad
 - Persistence on cutting board
 - Transfer from tap to hand
- Probabilities of action occurrence:
 - Probability (per meal) that chicken breast is prepared before salad
 - Probability (per meal) that hands are washed
 - Probability (per meal) that cutting board is washed
 - Probability (per meal) that salad is washed.

Control Variables

None.

Description of Actual Data Sample:

- *Initial N*: Literature search and number of abstracts identified were not described
- *Attrition (final N)*: Number of articles excluded and reasons for rejection were not described
- *Age*: No data
- *Ethnicity*: No data
- *Other relevant demographics*: No data
- *Anthropometrics*: No data
- *Location*: The Netherlands.

Summary of Results:

Key Findings

- Cross-contamination in the kitchen environment can contribute significantly to the risk of *Campylobacter* infection
- Cross-contamination of salad is most likely to occur via the hands of the cook, then via the cutting board and unlikely to occur via the water tap
- Whether the cutting board is washed in between the preparation of chicken meat and raw food items is more important to cross-contamination than whether the cook washed his or her hands in between these actions
- Simulation results showed that the single most effective action for reducing risk of cross-contamination and corresponding infection risk was cutting-board washing followed by hand washing and salad rinsing.

Other Findings

- The numbers of infected people are plotted against the multiplication factors. It is interesting to see that the sensitivity of infection frequency to transfer from chicken to hand and from hand to salad is higher than the transfer from chicken to cutting board and from cutting

board to salad. This difference is again a reflection of the high efficacy of washing the cutting board, which makes cross-contamination via the board route less probable than via the hand route. Simulations with a lower frequency of cutting board washing demonstrate that the pattern is reversed and the route via the cutting board becomes more dominant

- For the transfer probabilities related to washing activities, there was an increasing multiplication factor for the persistence probabilities, that is, a decreasing efficacy of the washing itself, all give rise to a higher number of the infected, but that hand washing has to be around an order of magnitude less effective and board washing around two orders of magnitude less effective before it has a noticeable effect. A more effective rinsing of the salad, however, has given the default parameter values an immediate effect. The number of infected does not depend on transfer from hand to tap only at a very high transfer from hand to tap, this has a lowering effect on the number of infected because the tap acts as a sink for bacteria.

Author Conclusion:

- Using parameter values from the literature and performing elementary sensitivity analyses, we show that cross-contamination can contribute significantly to the risk of *Campylobacter* infection and find that cleaning frequency of kitchen utensils and thoroughness of rinsing of raw food items after preparation, has more impact on cross-contamination than previously emphasized
- Furthermore, we argue that especially more behavioral data on hygiene during food preparation is needed for a comprehensive *Campylobacter* risk assessment.

Reviewer Comments:

- *Searching methodology and inclusion and exclusion criteria for articles not described*
- *There is currently no consensus on how to appraise the methodologic quality of risk assessment analysis. The quality assessment of this study was done using the quality appraisal tool for systematic review or meta-analysis. Thus the methodologic quality rating of this study may not represent the "true" quality of this study*
- *Based on reviewer's limited knowledge on simulation studies, this article appears to have good reporting on all the parameters in the analyses and provide good explanation for how the model was chosen and how to interpret the results. The assumptions and limitations on the simulation model were also provided.*

Research Design and Implementation Criteria Checklist: Review Articles

Relevance Questions

1.	Will the answer if true, have a direct bearing on the health of patients?	Yes
2.	Is the outcome or topic something that patients/clients/population groups would care about?	Yes
3.	Is the problem addressed in the review one that is relevant to nutrition or dietetics practice?	Yes
4.	Will the information, if true, require a change in practice?	Yes

Validity Questions

1.	Was the question for the review clearly focused and appropriate?	Yes
2.	Was the search strategy used to locate relevant studies comprehensive? Were the databases searched and the search terms used described?	No
3.	Were explicit methods used to select studies to include in the review? Were inclusion/exclusion criteria specified and appropriate? Were selection methods unbiased?	???
4.	Was there an appraisal of the quality and validity of studies included in the review? Were appraisal methods specified, appropriate, and reproducible?	No
5.	Were specific treatments/interventions/exposures described? Were treatments similar enough to be combined?	Yes
6.	Was the outcome of interest clearly indicated? Were other potential harms and benefits considered?	Yes
7.	Were processes for data abstraction, synthesis, and analysis described? Were they applied consistently across studies and groups? Was there appropriate use of qualitative and/or quantitative synthesis? Was variation in findings among studies analyzed? Were heterogeneity issues considered? If data from studies were aggregated for meta-analysis, was the procedure described?	Yes
8.	Are the results clearly presented in narrative and/or quantitative terms? If summary statistics are used, are levels of significance and/or confidence intervals included?	Yes
9.	Are conclusions supported by results with biases and limitations taken into consideration? Are limitations of the review identified and discussed?	Yes
10.	Was bias due to the review's funding or sponsorship unlikely?	Yes

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